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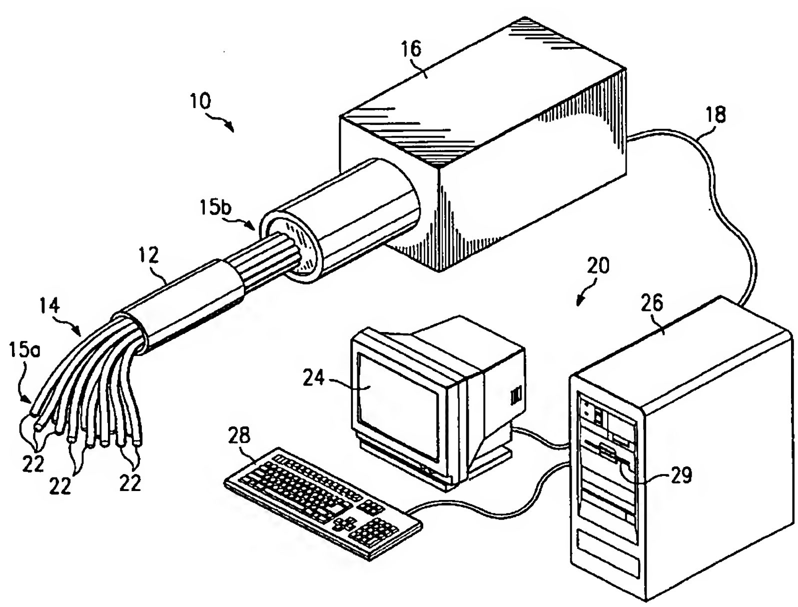
(54) **Title:** MULTI-POINT OPTICAL INSPECTION SYSTEM



(57) **Abstract:** A system and method is provided for receiving and viewing multiple images using multiple conduits capable of transmitting image data. The conduits are positioned at one end (15a) to capture the images to be viewed, and grouped together in a single cable (12) at the other end, proximate to a camera (16). The images are transmitted along the conduits to the camera (16), which receives the individual images as a single, combined image. The combined image can then be monitored and separated into individual images for further monitoring.

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MULTI-POINT OPTICAL INSPECTION SYSTEM

Field of the Invention

The present invention relates generally to video surveillance systems, and in particular, to the use of several optical conduits to simultaneously provide discrete images to the lens of a single camera.

Background of the Invention

There is a wide variety of video surveillance systems that are used in many different applications. For example, security systems provide video surveillance of a predefined area to safeguard people, persons and property in that area. Monitoring systems provide video surveillance of a manufacturing system to monitor safety and product quality, as well as to aid in the manufacturing process itself. For all these systems, it is a common desire to provide a maximum amount of surveillance with a minimum amount of expensive or obtrusive equipment.

In security systems, cameras are typically mounted in fixed positions at locations that provide the greatest possible viewing region per camera. Generally, several cameras are needed to properly view an area, which is often a residential building, office building, or retail establishment. Cameras can be positioned to view each door, window, and entryway, as well as locations that have a high incidence of theft, such as a cash register, display case, and/or dressing room. Alternatively, cameras are mounted with a motor for panning across the area under surveillance. The motor can pan the camera responsive to different commands, such as from a security guard at a remote station or a motion sensor to track movement. The motor can also pan the camera with a constant scanning motion.

In manufacturing plants, cameras are often placed along the production line to aid in production or to monitor safety and quality control. In these instances, multiple cameras would typically need to be positioned along the production line, often at each point along the line.

There are many problems associated with the above-described systems. With panning systems, blind spots occur as the camera moves and faces away from portions of the area to be secured, necessitating multiple cameras to prevent the blind spots. Further, the chance of failure of mechanical panning devices is considerably detrimental in the field of security and surveillance.

Further, for quality control, it is often necessary to view relatively small objects and relatively small areas in detail. In order for multiple small objects or areas to be viewed by a multiple cameras, enough space is required about the objects for the cameras to fit and to focus on the area or object to be viewed, thus increasing the size and costs of the manufacturing facility. Additionally, for quality control of small areas or details on larger objects, clustering multiple cameras together is not a feasible solution. Unfortunately, using multiple cameras in the above manners increases costs, and the chance of mechanical failure among a multitude of cameras increases accordingly.

Another attempted solution has been to use assemblies of mirrors and prisms in order to provide a fixed position security camera with greater surveillance capability. However, such mechanisms are limited in their directional ability, are costly, are obtrusive, and must be aligned and serviced in order to maintain the necessary reliability.

Summary of the Invention

In response to these and other difficulties, the present invention provides a multi-point optical inspection system. In one embodiment, the system allows the viewing of multiple images by using several conduits, such as the filaments of a fiber optic cable. Lenses are attached to one end of each conduit. Each conduit and lens are then positioned to view a specific image. The opposite end of the conduits are grouped together and placed proximate to an image receptor, such as a camera. As a result, the images at the areas to be observed are captured via the lenses attached to the conduits and transferred simultaneously to the camera. The resulting combined image can then be depicted or manipulated in any manner desired.

In some embodiments the camera is connected to a monitor or a monitoring system. The monitoring system is able to display the combined image or separate an individual image out from the combined image.

In another embodiment, the system can be used for monitoring a first and second portion of a predefined area. First and second lenses are attached to the distal ends of first and second conduits, respectively, and the lenses are positioned proximate to the first and second portions of the predefined area. The proximal ends of the conduits are grouped together and placed proximate to the camera. The images of the first and second portions of the predefined area are transferred simultaneously via the fiber optic cable to the camera,

and the resulting combined image can then be depicted or manipulated in any manner desired.

An advantage of the present invention is that video surveillance of an area can be provided with minimal cost or chance of mechanical failure.

Another advantage of the present invention is that a single camera can monitor images from several directions simultaneously, and further, can monitor images from different locations simultaneously without additional costly equipment.

A further advantage of the present invention is that a single camera can monitor many small areas, objects, or locations that are too small for multiple cameras to effectively monitor.

Yet another advantage of the present invention is that an attachment for a standard commercially available camera is able to generate separate images of different areas for simultaneous display on a standard commercially available monitor without additional electronic modifications.

Brief Description of the Drawings

Fig. 1 is a side view of a multi-point optical inspection system according to one embodiment of the present invention.

Fig. 2 is perspective view of a room according to one application of the multi-point optical inspection system of Fig. 1.

Fig. 3 shows a combined image produced from multiple images received by the system of Fig. 1.

Fig. 4 is a perspective view of a room using an alternate embodiment of the present invention.

Fig. 5 is an exemplary screen shot from a monitoring system in the system of Fig. 4.

Fig. 6 is a representation of the system similar to Fig. 2.

Fig. 7 shows a combined image produced from multiple images received by the system of Fig. 6.

Fig. 8 is a representation of a further use of the system similar to Fig. 2.

Fig. 9 shows a combined image produced from multiple images received by the system of Fig. 8.

Description of the Preferred Embodiments

The preferred embodiments of a multi-point optical inspection system will now be described in detail. Referring generally to Fig. 1, the system 10 comprises a cable 12, an image receptor 16, a bus 18, and a monitoring system 20. In one embodiment, the image receptor 16 is a standard Charge-Coupled Device (CCD) camera, although the image receptor 16 can be a broad range of security cameras and lenses, or can even be a lens without a camera coupled directly to the bus 18. The CCD camera 16 works by providing an array of pixels on a silicon substrate, which records light as an electrical signal and then digitizes the electrical signal for transmission via the bus 18 to the monitoring system 20. The bus 18 can be any serial, parallel, wired, or wireless means for communicating or sending data.

The monitoring system 20 comprises a monitor 24, and can further include a processor 26 or an input device 28. There can be one or more monitors 24, and the input device 28 can be a mouse, keyboard, tablet device, or any other form of input device. In addition, multiple processors 26 can be incorporated into the monitoring system 20, as well as linking multiple monitoring systems 20 together. Further, the monitoring system 20 could include a storage device 29 such as a video cassette recorder, a hard drive, or a digital video disc burner.

The cable 12 is preferably a fiber optic cable or other cable that is composed of numerous conduits that allow the transmission of light from one point to another. In one embodiment, the cable 12 is composed of glass filaments 14, and to a distal end 15a of each filament 14 is attached a lens 22. The proximal ends 15b of the filaments 14 are grouped together and placed against the camera 16.

Referring to Fig. 2, for the sake of example, a room 30 is shown having three areas to be viewed, 32a, 32b, and 32c. In operation, the distal ends 15a of three separate filaments (designated as filaments 14a, 14b, and 14c) are aligned so that the respective lenses 22 face the respective areas 32a, 32b, 32c. As light is collected by the lenses 22, the filaments 14 act as conduits that pass the light along the cable 12 to the camera 16.

Referring also to Fig. 3, the camera 16 receives the individual images of areas 32a, 32b, and 32c passed through the filaments 14a, 14b, and 14c as a single, aggregated image 34. This image 34 is then sent by the bus 18 (Fig. 2) to the monitoring system 20.

After receiving the image 34, the monitoring system 20 can analyze the image 34, such as detecting motion or changes in ambient lighting or color. The monitoring system 20

can also receive input or commands to isolate a single image, so that, for example, only area 32a is displayed on monitor 24 rather than image 34. The monitoring system 20 may also record the aggregate image 34 or a single image 32 onto the storage device 29 for later viewing or archive purposes. Further, the monitoring system 20 may also display the image 34, any single image 32, or any combination of images on the monitor 24. In the case of multiple monitors 24, the monitoring system 20 can also segregate the image 34 into the images 32 for display on the multiple monitors 24.

Referring now to Fig. 4, in another embodiment, the system 10 includes one or more additional response devices 36. In this embodiment, when the monitoring system 20 receives the images of areas 32d, 32e, and 32f, the monitoring system 20 may respond by manipulating, activating, or using (or provide a means for a user to do so) the additional response device 36 via a bus 38.

In a security setting, a response device 36 may be one or more image receptors 16, floodlights, speakers, two-way communications devices, or any other common security system devices. These response devices 36 may serve as redundant systems, or provide visual or audio deterrence. Where the response device 36 is a camera, the camera can provide additional resolution, zoom or recording features, infrared or night imaging, or other video features. A speaker could also be used as a response device 36 to provide warning, notification to nearby persons, audio deterrence, or communication means for a user stationed at the monitoring system 20. As a light, the response device 36 could provide deterrence and warning. In a manufacturing setting, the additional response devices 36 could be a mechanical arm or another device to manipulate or modify the objects being observed.

It is important to note that, while the response device 36 is depicted in Fig. 4 as a camera protruding from the ceiling, the response devices 36 could be located on the floor or walls, as well as being integral to or resting on furniture or manufacturing equipment.

Fig. 5 illustrates a snap shot of several images from Fig. 4. The individual images 32d, 32e, and 32f, are shown on the monitor 24. The door in area 32f has opened, thus triggering the monitoring system's 20 motion detection algorithm. In response, the monitoring system 20 has panned the response device 36 to also face area 32f to provide additional visual feedback as shown. Although motion detection has been used in this example, other algorithms could be used, such as ambient light analysis, security-related

algorithms, manufacturing-related algorithms, or scientific-related algorithms that would be known or developed by a person of ordinary skill in the art.

Referring now to Fig. 6, in yet another embodiment, the monitoring system 10 can be placed to monitor changes to chemical compositions 41 contained in scientific apparatuses 42. In this application, the distal ends 15a of filaments 14 are placed into test tubes, petri dishes, beakers, or any other containers. The filaments 14 pass the images of the compositions 41 along the cable 12 to the camera 16.

Referring also to Fig. 7, the camera 16 receives the individual images of chemical compositions 41 as a single, aggregated image 46. This image 46 is then sent by the bus 18 to the monitoring system 20. The monitoring system 20 can then monitor changes in the chemical compositions 41, such as, for example, color change or liquid level change.

Referring to Fig. 8, in still another embodiment, the system 10 can be used in a manufacturing setting to view a multitude of objects 44 that need to be monitored. In this application, the distal ends 15a of filaments 14 are placed over the objects 44. As the objects 44 are moved along the assembly line 50 (or alternatively, the filaments 14 could move relative to the objects 44), the lenses 22 receive the images of the objects 44 and the filaments 14 transfer the images to the camera 16. In this embodiment, since the cable 12 may be placed adjacent the camera 16 without actually connecting to the camera 16, the cable 12 can be easily rotated. As the cable 12 rotates, the filaments 14 are correspondingly rotated as they move with the assembly line 50. As a result, the images produced by the camera 16 also rotate, accordingly.

Referring also to Fig. 9, the camera 16 receives the aggregate image 48, which is sent into the monitoring system 20. The monitoring system can then analyze the aggregate image 34 to monitor the status of the objects 44. The status of the objects may be monitored for quality control purposes or to aid in the manufacturing of the objects, such as, for example, determining that the orientation of the objects 44 is not correct for further manufacturing purposes.

Although preferred embodiments of the invention have been described in the foregoing detailed description and illustrated in the accompanying drawings, it will be understood that the invention is not limited to the embodiments disclosed, but is capable of numerous rearrangements and modifications and substitutions of parts and elements without departing from the spirit of the invention. Accordingly, the present invention is

intended to encompass such rearrangements, modifications and substitutions or parts and elements as fall within the spirit and scope of the appended claims.

Claims

WHAT IS CLAIMED IS:

1. An optical system for viewing a plurality of images comprising:

a plurality of conduits capable of transmitting image data that are individually positionable at a first end and grouped together at a second end;

a plurality of lenses corresponding to the plurality of conduits, wherein each of the plurality of lenses is attached to the first end of each of the plurality of conduits; and

an image receptor proximate to the grouped second ends of the plurality of conduits.

2. The optical system of claim 1, further comprising:

a monitor connected to the image receptor.

3. The optical system of claim 1, further comprising:

a monitoring system connected to the image receptor.

4. The optical system of claim 3, further comprising:

a response device connected to the monitoring system.

5. A method for viewing a first and second image, comprising the steps of:

providing a first and second conduit for transmitting image data;

attaching a first lens to a first end of the first conduit, and attaching a second lens to a first end of the second conduit;

placing the first lens proximate to the first image to be viewed, and placing the second lens proximate to the second image to be viewed;

grouping the second end of the first conduit and the second end of the second conduit together;

providing an image receptor proximate to the grouped second ends of the first and second conduits;

receiving the first image at the first lens and receiving the second image at the second lens;

transmitting the first and second images to the image receptor via the first and second conduits, respectively; and

receiving the first and second images simultaneously at the image receptor.

6. The method of claim 5, further comprising the steps of:

providing at least one monitor connected to the image receptor;

transmitting a combined image comprising the first and second images received at the image receptor to the at least one monitor; and

displaying the combined image on the at least one monitor.

7. The method of claim 5, further comprising the steps of:

providing a processor connected to the image receptor;

transmitting a combined image comprising the first and second images received at the image receptor to the processor; and

separating the first image from the combined image.

8. The method of claim 7, further comprising the steps of:

providing at least one monitor connected to the processor; and

displaying the first image on the at least one monitor.

9. The method of claim 7, further comprising the steps of:

providing at least one response device attached to the processor; and

manipulating the at least one response device in response to the first image.

10. The method of claim 9, wherein the at least one response device is manipulated in response to a change in ambient light in the first image.

11. The method of claim 9, wherein the at least one response device is manipulated in response to motion in the first image.

12. A system for monitoring a first and second portion of a predefined area, comprising:

a first and second conduit capable of transmitting image data, wherein the distal ends of the first and second conduits are individually positionable, and the proximal ends of the first and second conduits are grouped together;

a first and second lens coupled to the distal ends of the first and second conduits, respectively, and wherein the first and second lenses are positioned proximate to the first and second portions of the predefined area; and

an image receptor proximate to the proximal ends of the first and second conduits.

13. The system of claim 12 wherein the predefined area is a residential building.

14. The system of claim 12 wherein the predefined area is an office building.

15. The system of claim 12 wherein the predefined area is a retail establishment.

16. The system of claim 12 wherein the predefined area is a manufacturing plant.

17. The system of claim 12, further comprising:
a monitor connected to the image receptor.

18. The system of claim 12, further comprising:
a monitoring system connected to the image receptor.

19. The system of claim 18, further comprising:
a response device connected to the monitoring system.

20. A system for monitoring a status of first and second components, comprising:

a first and second conduit capable of transmitting image data, wherein the distal ends of the first and second conduits are individually positionable, and the proximal ends of the first and second conduits are grouped together;

a first and second lens coupled to the distal ends of the first and second conduits, respectively, and wherein the first and second lenses are positioned proximate to the first and second components, respectively; and

an image receptor proximate to the grouped proximal ends of the first and second conduits.

21. The system of claim 20, wherein the first and second components are chemical compositions.

22. The system of claim 21, wherein the status of the chemical compositions changes based on a chemical reaction.

23. The system of claim 20, wherein the first and second components are objects in a manufacturing process.

24. The system of claim 23, wherein the status of the first object changes based on the orientation of the first object.

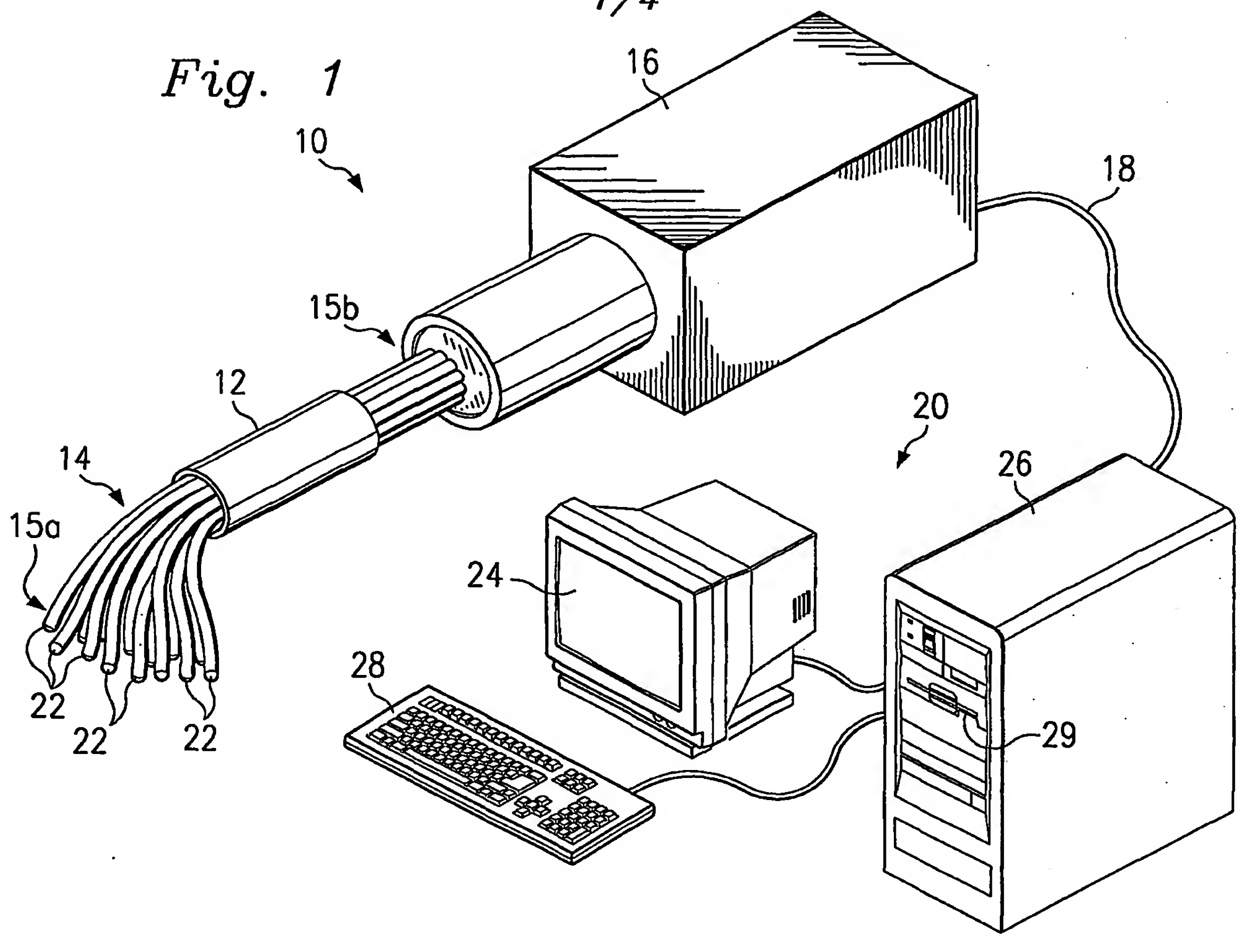
25. The system of claim 23, wherein the status of the first object changes based on the quality of the first object.

26. The system of claim 20, further comprising:
a monitor connected to the image receptor.

27. The system of claim 20, further comprising:
a monitoring system connected to the image receptor.

28. The system of claim 27, further comprising:
a response device connected to the monitoring system.

Fig. 1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15b
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15a
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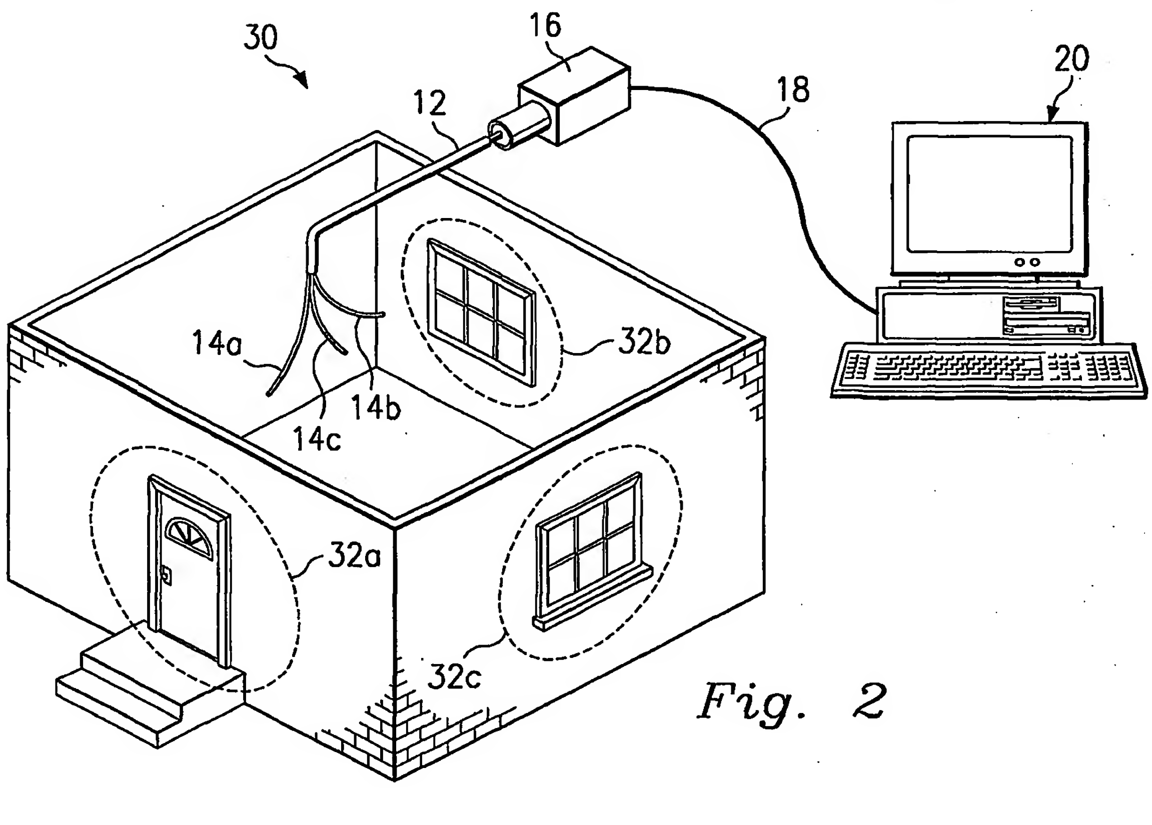
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14b
32a
32c

Fig. 2

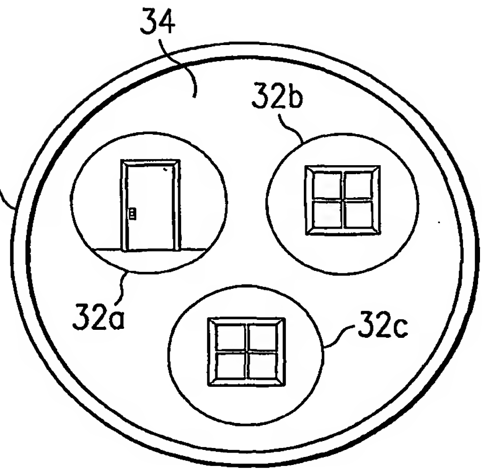


Fig. 3

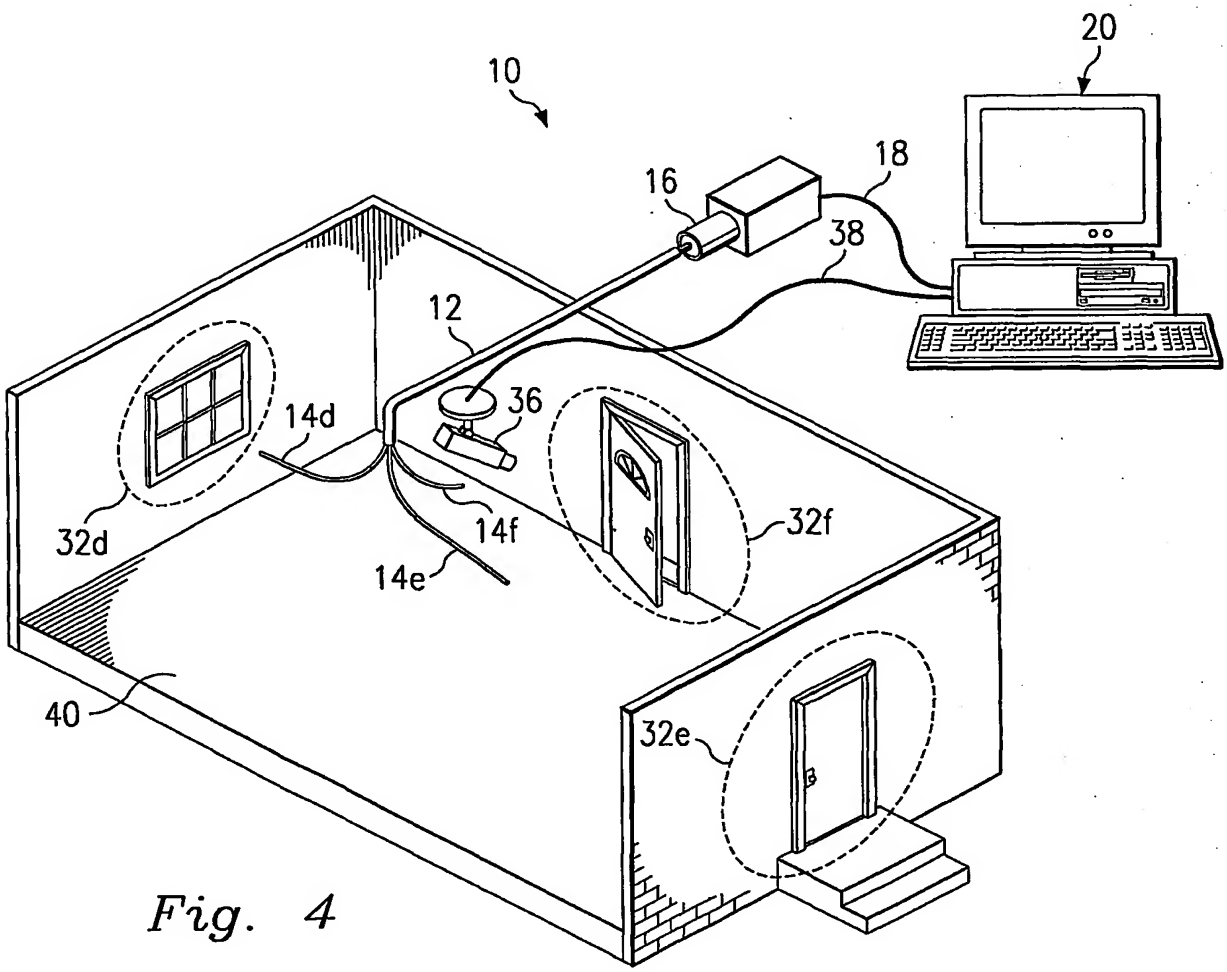
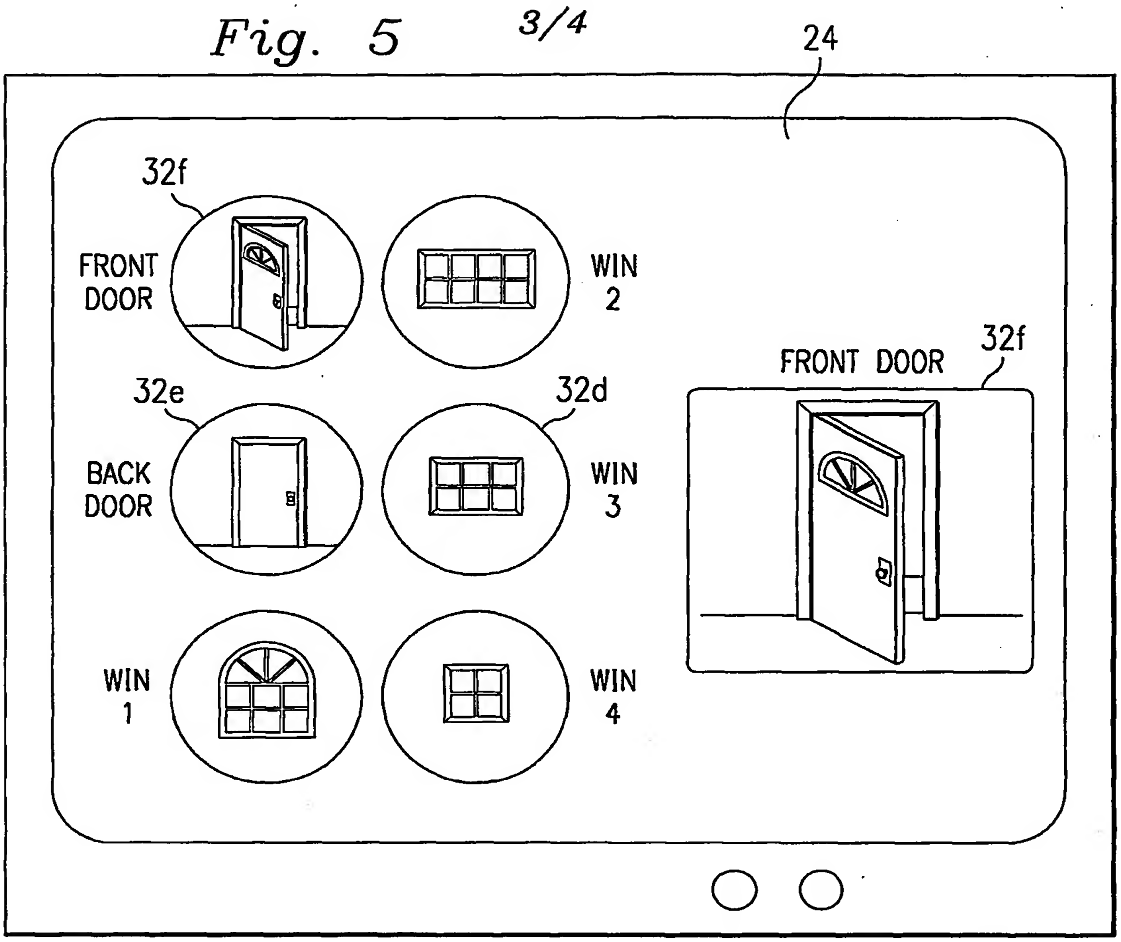


Fig. 4

Fig. 5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32f
FRONT DOOR
WIN 2
32e
32d
BACK DOOR
WIN 3
WIN 1
WIN 4
FRONT DOOR
32f

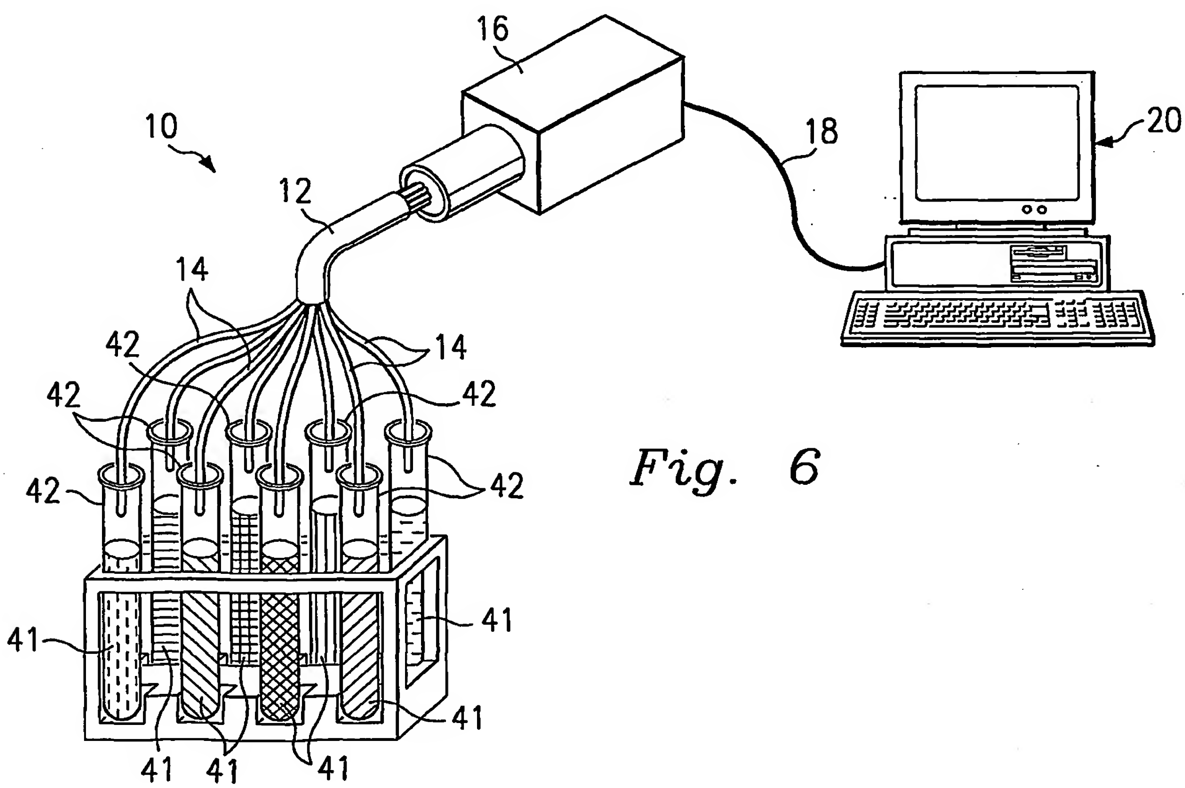
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Fig. 6

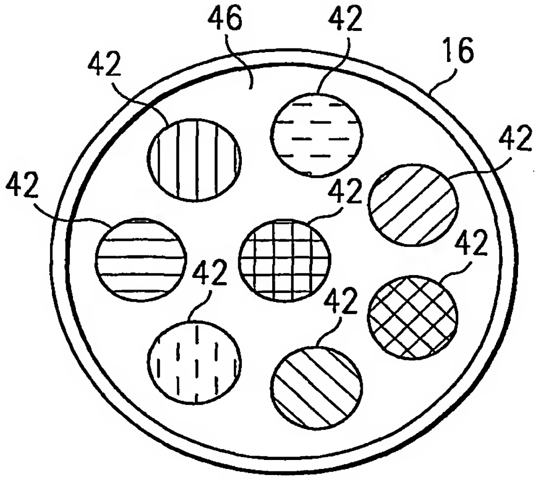

Fig. 7

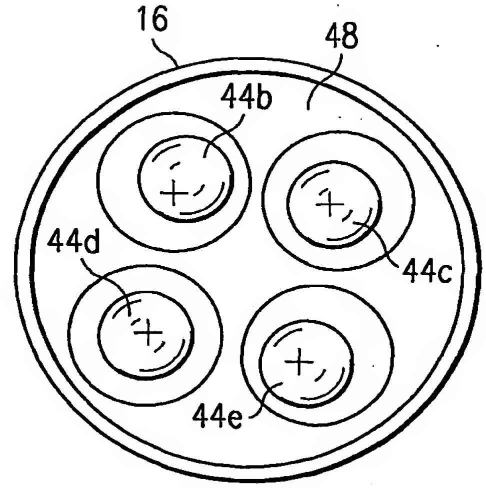

Fig. 9

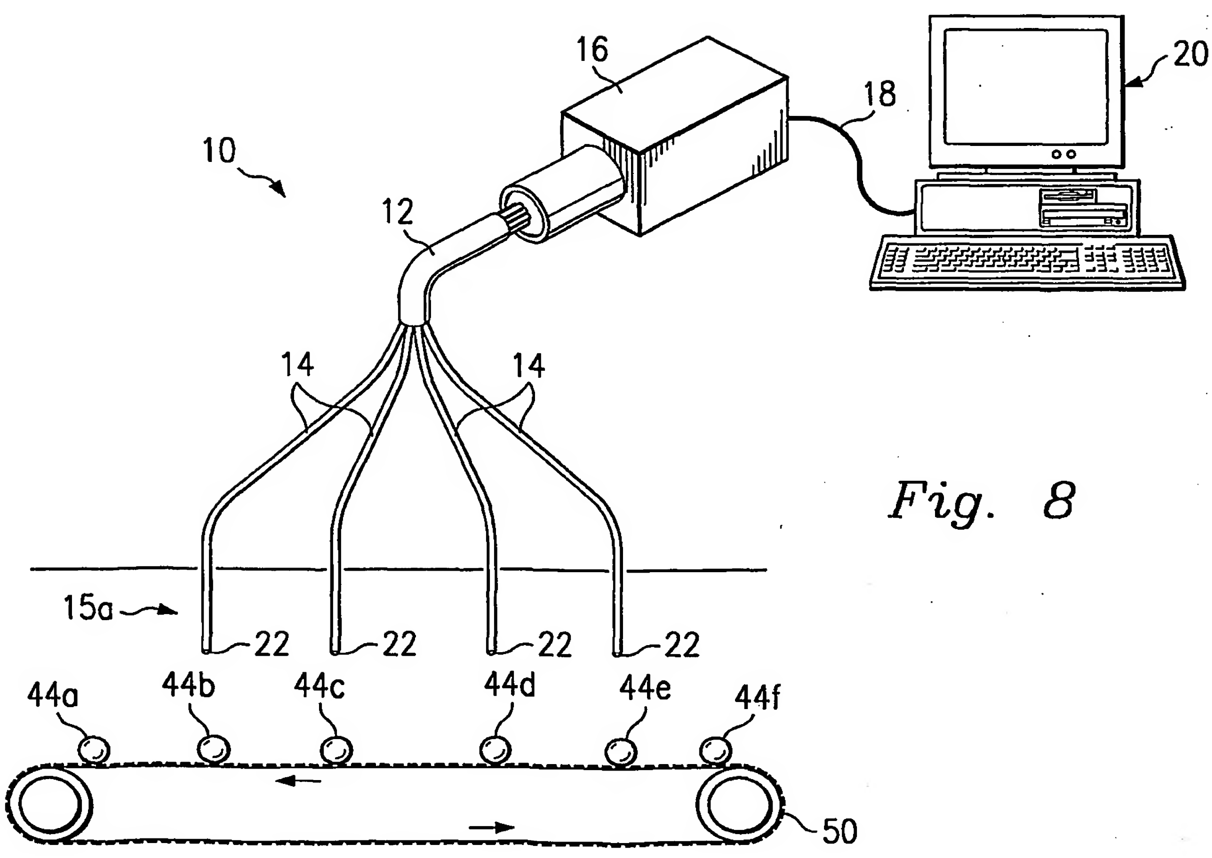

Fig. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/22857

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :G06K 7/10, 9/36; G01R 31/02; G01N 21/88; G02B 27/14
US CL : 382/321, 284; 324/758; 356/237.1; 359/630
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 382/321, 284; 324/758; 356/237.1; 359/630

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
None

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EAST

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,321,351 A (SWART ET AL) 14 JUNE 1994, Figs. 12, 14; col. col. 9, lines 50-53; col. 10, lines 24-28	1-28
Y	US 6,057,966 A (CARROLL ET AL) 02 MAY 2000, col. 4, lines 50-53; col. 5, lines 27-28; col. 6, lines 40-48; col. 8, lines 21-34; col. 10, lines 27-33	1-28
Y	US 5,936,725 A (PIKE et al.), 10 August 1999, col. 6, lines 23-28; col. 7, lines 24-42	1-28

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"&" document member of the same patent family

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